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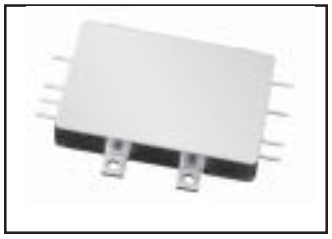
International
IOR Rectifier

PD - 94519A

L-SERIES

+ 28V Input, Single/Dual Output

ADVANCED ANALOG HIGH RELIABILITY RADIATION TOLERANT DC/DC CONVERTERS



Description

The L-Series of DC/DC converters are radiation tolerant, high reliability devices designed for moderate radiation environments such as those encountered by low earth orbit satellites and launch vehicles. For higher radiation environments, the G-Series of DC/DC converters is recommended. Features include small size, low weight and a high tolerance to total ionizing dose, single event effects and environmental stresses such as temperature extremes, mechanical shock, and vibration. All components are fully derated to meet the requirements of MIL-STD-975 and MIL-STD-1547 and GSFC PPL-21 Appendix B. Extensive documentation including Radiation Susceptibility, Thermal Analysis, Stress Analysis and MTBF are available.

The converters incorporate a fixed frequency single forward topology with magnetic feedback and an internal EMI filter. These converters are capable of meeting the conducted emissions and conducted susceptibility requirements of MIL-STD-461C without any additional components. All models include an external inhibit port and have an adjustable output voltage. They are enclosed in a hermetic 1.5" x 2.3" x 0.425" steel package and weigh less than 85 grams. The package utilizes rugged ceramic feed-through copper core pins and is sealed using parallel seam welding.

Full environmental screening includes temperature cycling, constant acceleration, fine and gross leak, and burn-in.

Non-flight versions of the L-Series converters are available for system development purposes. Variations in electrical specifications and screening to meet custom requirements can be accommodated.

Features

- Total Dose > 25K Rad(Si)
- SEE > 37 MeV•cm²/mg
- Internal EMI filter; Converter Capable of meeting MIL-STD-461C CE03 and CS01
- Low Weight, < 85 grams
- Magnetically Coupled Feedback
- 16V to 50V DC Input Range
- Up to 25W Output Power
- Single and Dual Output Models Include 3.3, 5, 12, 15, ±5, ±12 and ±15V
- High Efficiency - to 82%
- -55°C to +125°C Operating Temperature Range
- 100MΩ @ 500VDC Isolation
- Under-Voltage Lockout
- Short Circuit and Overload Protection
- Output Over Voltage Limiter
- Adjustable Output Voltage
- External Inhibit
- 1,500,000 Hour MTBF

Applications

- Low Earth Orbit Satellites (LEO)
- Launch Vehicles

Circuit Description

The L-Series converters utilize a single-ended forward topology with resonant reset. The nominal switching frequency is 500kHz. Electrical isolation and tight output regulation are achieved through the use of a magnetically coupled feedback. Voltage feed-forward with duty factor limiting provides high line rejection and protection against output over voltage in the event of an internal control loop failure. This mechanism limits the maximum output voltage to approximately 20% over the nominal regardless of the line voltage.

An internal EMI filter allows the converter to meet the conducted emissions requirements of MIL-STD-461C on the input power leads. A single-stage output filter reduces the typical output ripple to less than 50mV peak-to-peak.

Output current is limited under any load fault condition to approximately 125% of rated. An overload condition causes the converter output to behave like a constant current source with the output voltage dropping below nominal. The converter will resume normal operation when the load current is reduced below the current limit point. This protects the converter from both overload and short circuit conditions. The current limit point exhibits a slightly negative temperature coefficient to reduce the possibility of thermal runaway.

An external inhibit port is provided to control converter operation. The converter's operation is inhibited when this pin is pulled low. It is intended to be driven by an open collector logic device. The pin may be left open for normal operation and has a nominal open circuit voltage of 10.5V with respect to the input return (pin 2).

The output voltage of all models can be adjusted using a single external resistor.

Design Methodology

The L-Series was developed using a proven conservative design methodology which includes selecting radiation tolerance and established reliability components and fully derating to the requirements of MIL-STD-975 and MIL-STD-1547. Heavy derating of the power MOSFET gate and drain voltages minimize the possibility of SEGR and SEB. A magnetic feedback circuit is utilized instead of opto-couplers to minimize temperature, radiation and aging sensitivity. PSPICE was used extensively to predict and optimize circuit performance for both beginning and end-of-life. Thorough design analyses include Radiation Susceptibility (TREE), Stress, Thermal, and Reliability (MTBF).

Absolute Maximum Ratings

Input voltage range - -0.5Vdc to +60Vdc
Output power - Internally limited
Lead temperature - +300°C for 10 seconds
Operating temperature - -55°C to +135°C
Storage temperature - -55°C to +135°C

Recommended Operating Conditions

Input voltage range - 16Vdc to +60Vdc
Input voltage range[1] - 16Vdc to +38Vdc
Output power - 0 to Max. Rated
Operating temperature[2] - -55°C to +125°C
Operating temperature[1] - -55°C to +70°C

[1] Meets derating per MIL-STD-975
[2] For operation at +125°C see table note 13

Electrical Performance Characteristics

Parameter	Group A Subgroup	Conditions -55°C ≤ T_C ≤ +85°C V_{IN} = 28V DC ± 5%, C_L = 0 unless otherwise specified	Limits			Unit
			Min	Nom	Max	
Input Voltage			18	28	50	V
Output Voltage (Vout)						
M3L2803R3S	1	I_{OUT} = 100% rated load	3.27	3.30	3.33	V
M3L2805S	1	Note 4	4.95	5.00	5.05	V
M3L2812S	1		11.88	12.00	12.12	V
M3L2815S	1		14.85	15.00	15.15	V
M3L2805D	1		±4.95	±5.00	±5.05	V
M3L2812D	1		±11.88	±12.00	±12.12	V
M3L2815D	1		±14.85	±15.00	±15.15	V
M3L2803R3S	2,3	I_{OUT} = 100% rated load	3.23		3.37	V
M3L2805S	2,3	Note 4	4.90		5.10	V
M3L2812S	2,3		11.76		12.24	V
M3L2815S	2,3		14.70		15.30	V
M3L2805D	2,3		±4.90		±5.10	V
M3L2812D	2,3		±11.76		±12.24	V
M3L2815D	2,3		±14.70		±15.30	V
Output power (P_{OUT})						
M3L2803R3S	1,2,3	V_{IN} = 16, 28, 50 Volts, Note 2	0		20	W
All Others			0		25	W
Output current (I_{OUT})						
M3L2803R3S	1,2,3	V_{IN} = 16, 28, 50 Volts, Note 2	0		6.06	A
M3L2805S			0		5.00	A
M3L2812S			0		2.08	A
M3L2815S			0		1.67	A
M3L2805D		Either Output, Note 3	0		4.00	A
M3L2812D		Either Output, Note 3	0		1.67	A
M3L2815D		Either Output, Note 3	0		1.33	A
Line regulation (VR_{LINE})	1,2,3	V_{IN} = 16, 28, 50 Volts I_{OUT} = 0, 50%, 100% rated, Note 4	-0.5		0.5	%
Load regulation (VR_{LOAD})	1,2,3	I_{OUT} = 0, 50%, 100% rated, Note 4 V_{IN} = 16, 28, 50 Volts	-1.0		1.0	%
Cross regulation (VR_{CROSS})						
M3L2805D	1,2,3	V_{IN} = 16, 28, 50 Volts	-5.0		5.0	%
M3L2812D		Duals only, Note 5	-3.0		3.0	%
M3L2815D			-3.0		3.0	%

For Notes to Specifications, refer to page 5

Electrical Performance Characteristics (continued)

Parameter	Group A Subgroup	Conditions -55°C ≤ T_C ≤ +85°C V_{IN} = 28V DC ± 5%, C_L = 0 unless otherwise specified	Limits			Unit
			Min	Nom	Max	
Input current, no load (I_{IN})						
M3L2803R3S	1,2,3	I_{OUT} = 0, Pin 4 open			60	mA
M3L2805S					70	mA
M3L2812S					70	mA
M3L2815S					70	mA
M3L2805D					70	mA
M3L2812D					100	mA
M3L2815D					100	mA
Input current inhibited	1,2,3	Pin 4 shorted to pin 2			8	mA
Output ripple (V_{RIP})						
M3L2803R3S	1,2,3	V_{IN} = 16, 28, 50 Volts			35	mV p-p
M3L2805S		I_{OUT} = 100% rated load			50	mV p-p
M3L2812S		Notes 4, 6			70	mV p-p
M3L2815S					80	mV p-p
M3L2805D					80	mV p-p
M3L2812D					80	mV p-p
M3L2815D					80	mV p-p
Switching frequency (F_S)	1,2,3	Sync. Input (Pin 4) open	425	500	575	KHz
Efficiency (E_{FF})						
M3L2803R3S	1,2,3	I_{OUT} = 100% rated load	68	75		%
M3L2805S		Note 4	75	79		%
M3L2812S			75	80		%
M3L2815S			75	81		%
M3L2805D			75	79		%
M3L2812D			75	79		%
M3L2815D			75	80		%
Enable Input (Inhibit Function)						
open circuit voltage	1,2,3	Note 1	9.5		11.5	V
drive current (sink)					500	µA
voltage range			-0.5		50	V
Current Limit Point Expressed as a percentage of full rated load current	1,2,3	V_{out} = 90% of Nominal, Note 4	105		130	%
Power dissipation, load fault (P_D)	1,2,3	Short Circuit, Overload, Note 8			14	W
Output response to step load changes (V_{TLD})	4,5,6	Half Load to/from Full Load, Notes 4,9	-300		300	mV pk
Recovery time, step load changes (T_{TLD})	4,5,6	Half Load to/from Full Load, Note 4,9,10			200	µS
Output response to step line changes (V_{TLN})	4,5,6	16V to/from 50V I_{OUT} = 100% rated load, Notes 1,4,11	-300		300	mV pk
Recovery Time, step line changes (T_{TLN})	4,5,6	16V to/from 50V I_{OUT} = 100% rated load, Notes 1,4,10,11			200	µS
Turn-on Response						
Overshoot (V_{OS})	4,5,6	No Load, Full Load			500	mV
Turn-on Delay (T_{DLY})		Notes 4,12	2		10	mS

For Notes to Specifications, refer to page 5

Electrical Performance Characteristics (continued)

Parameter	Group A Subgroup	Conditions -55°C ≤ T_C ≤ +85°C V_{IN} = 28V DC ± 5%, C_L = 0 unless otherwise specified	Limits			Unit
Capacitive Load (CL)						
M3L2803R3S	1	I_{OUT} = 100% rated load			2200	µF
M3L2805S		No effect on DC performance			1000	µF
M3L2812S		Notes 1, 4, 7			180	µF
M3L2815S					120	µF
M3L2805D					500	µF
M3L2812D		Each output on duals			90	µF
M3L2815D					60	µF
Line Rejection	1	I_{OUT} = 100% rated load DC to 50KHz, Notes 1, 4	40	50		dB
Isolation	1	Input to Output or Any Pin to Case except pin 3, test @ 500VDC	100			MΩ
Device Weight					85	grams
MTBF		MIL-HDBK-217F2, SF, 35°C	1.5×10^6			Hours

Table I. Electrical Performance Characteristics - notes

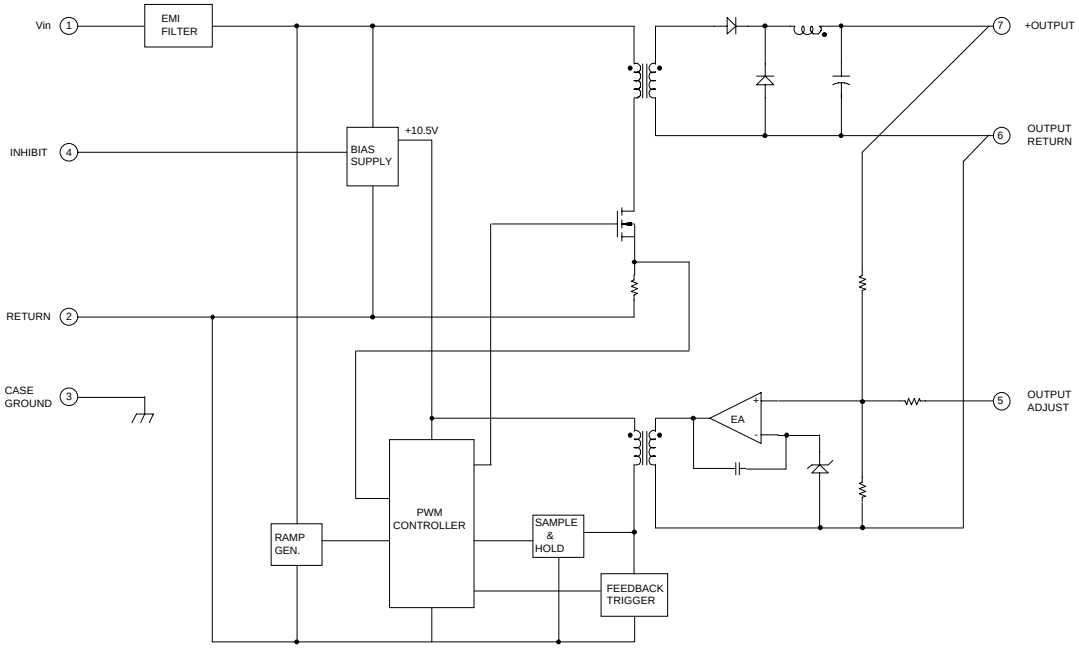
1) Parameter is tested as part of design characterization or after design changes. Thereafter, parameter shall be guaranteed to the limits specified.
2) Parameter verified during line and load regulation tests.
3) Output load current must be distributed such that at least 20% of the total load current is being provided by one of the outputs.
4) Load current split equally between outputs on dual output models.
5) Cross regulation is measured with 20% rated load on output under test while changing the load on the other output from 20% to 80% of rated.
6) Guaranteed for a D.C. to 20MHz bandwidth. Tested using a 20KHz to 10MHz bandwidth using the circuit shown below.
7) Capacitive load may be any value from 0 to the maximum limit without compromising dc performance. A capacitive load in excess of the maximum limit may interfere with the proper operation of the converter's overload protection, causing erratic behavior during turn-on.
8) Overload power dissipation is defined as the device power dissipation with the load set such that V_{OUT} = 90% of nominal.
9) Load step transition time ≤ 10 µSec.
10) Recovery time is measured from the initiation of the transient to where V_{OUT} has returned to within ±1% of its steady state value.
11) Line step transition time ≤ 100 µSec.
12) Turn-on delay time from either a step application of input power or a logic low to a logic high transition on the inhibit pin (pin 4) to the point where V_{OUT} = 90% of nominal.
13) For operation at temperatures between +85°C and +125°C, derate the maximum output power linearly from 100% to 75%.

Radiation Performance Characteristics

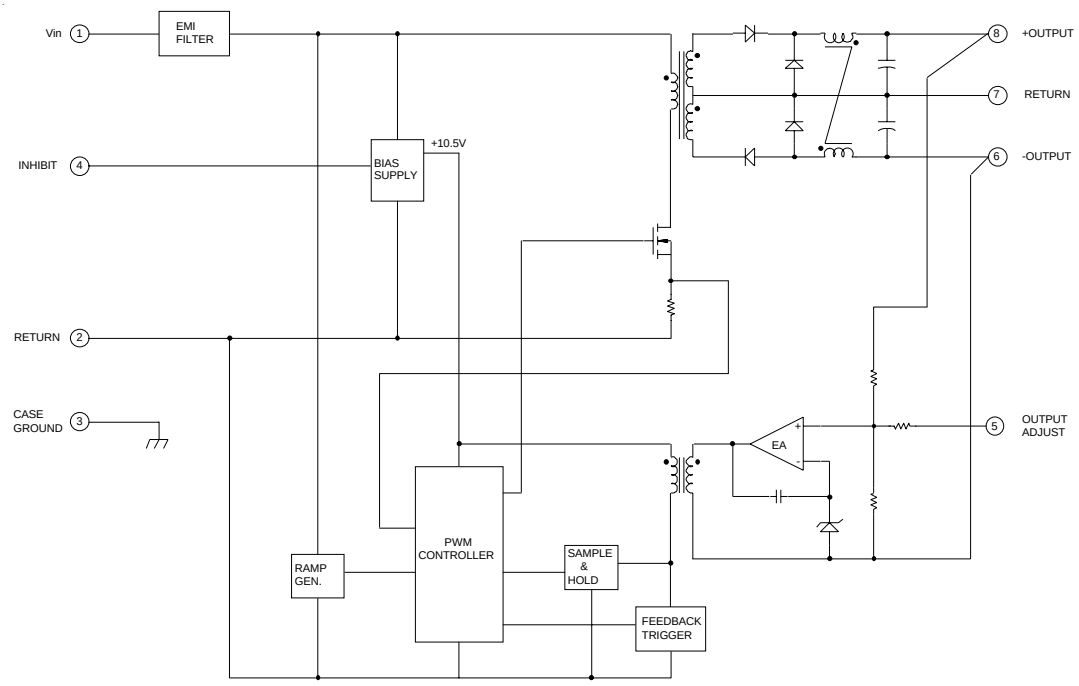
Test	Conditions	Min	Typ	Highest Level Tested	Unit
Total Ionizing Dose (Gamma)	MIL-STD-883, Method 1019 Operating bias applied during exposure, Full Rated Load, V_{IN} = 28V	25	40	60	KRads (Si)
Single Event Effects SEU, SEL, SEGR, SEB	Heavy ions (LET) Operating bias applied during exposure, Full Rated Load, V_{IN} = 28V	37	82	82	MeV•cm^2 /mg
Dose Rate (Gamma Dot) Temporary Saturation Survival	MIL-STD-883, Method 1023 Operating bias applied during exposure, Full Rated Load, V_{IN} = 28V	 1E8 1E10		1.5E9	Rads (Si)/sec
Neutron Fluence	MIL-STD-883, Method 1017	3E12		8E12	Neutrons /cm^2
Proton Fluence	E > 10MeV	TBD		N/A	protons /cm^2

Device Screening

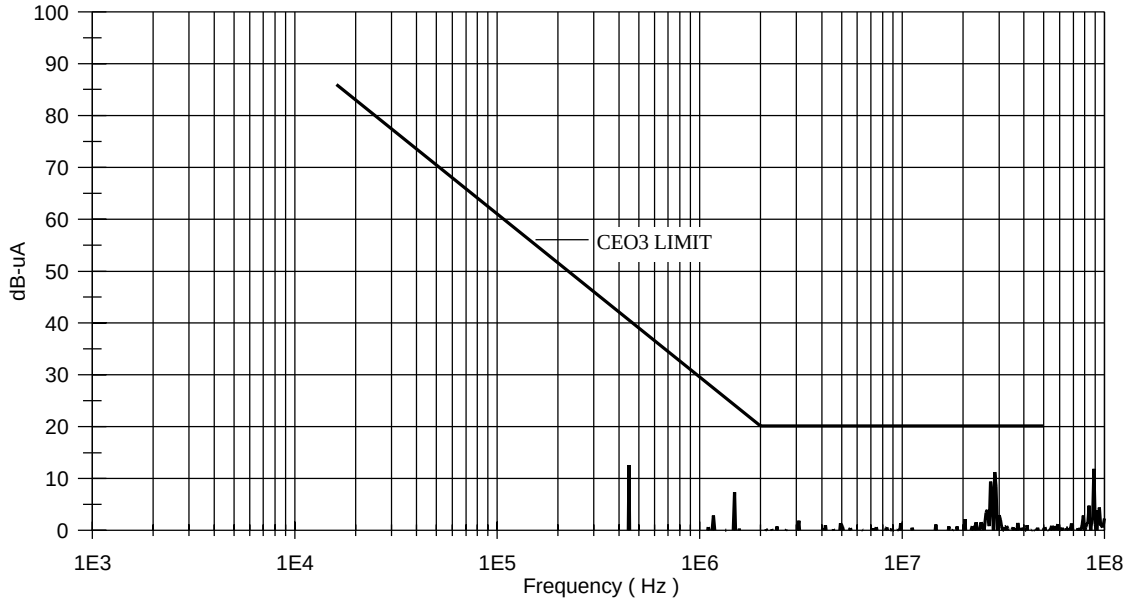
Test Inspection	Method	Condition
Element Evaluation	MIL-PRF-38534 class H equivalent with SEM	
Nondestructive Bond Pull	MIL-STD-883, Method 2023	
Internal Visual	MIL-STD-883, Method 2017	
Temperature Cycling	MIL-STD-883, Method 1010	C
Constant Acceleration	MIL-STD-883, Method 2001 (2k-g)	A, Y1 axis only
Electrical	In accordance with device specification	
Burn-in	MIL-STD-883, Method 1015	160 Hours
Final Electrical (Group A)	In accordance with device specification	
Seal Fine Leak Gross Leak	 MIL-STD-883, Method 1014	 A1 C
External Visual	MIL-STD-883, Method 2009	



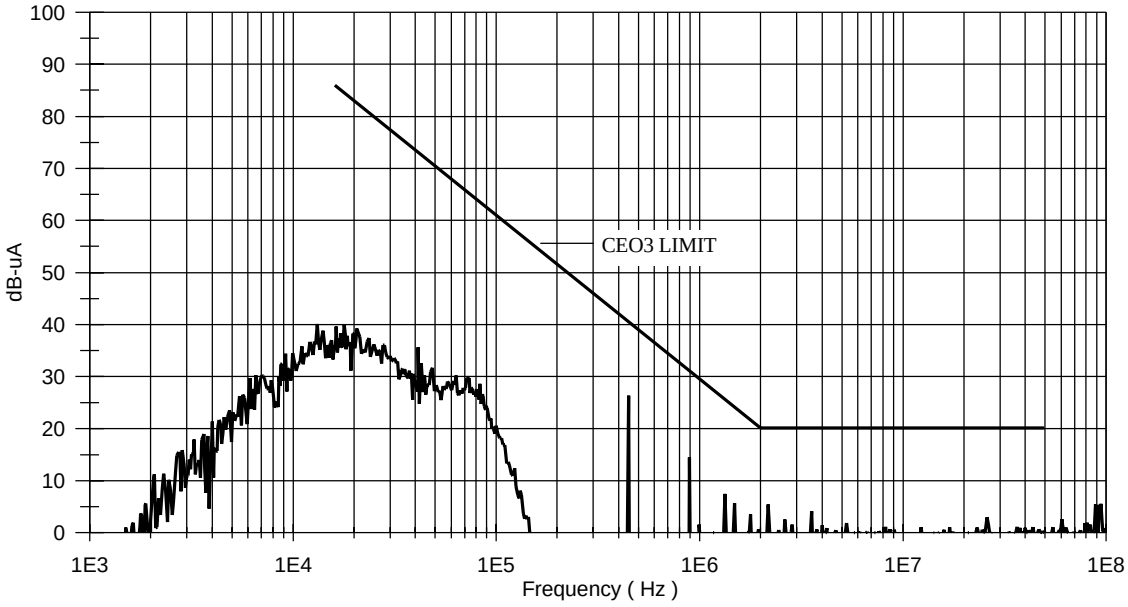
Block Diagram - Single Output



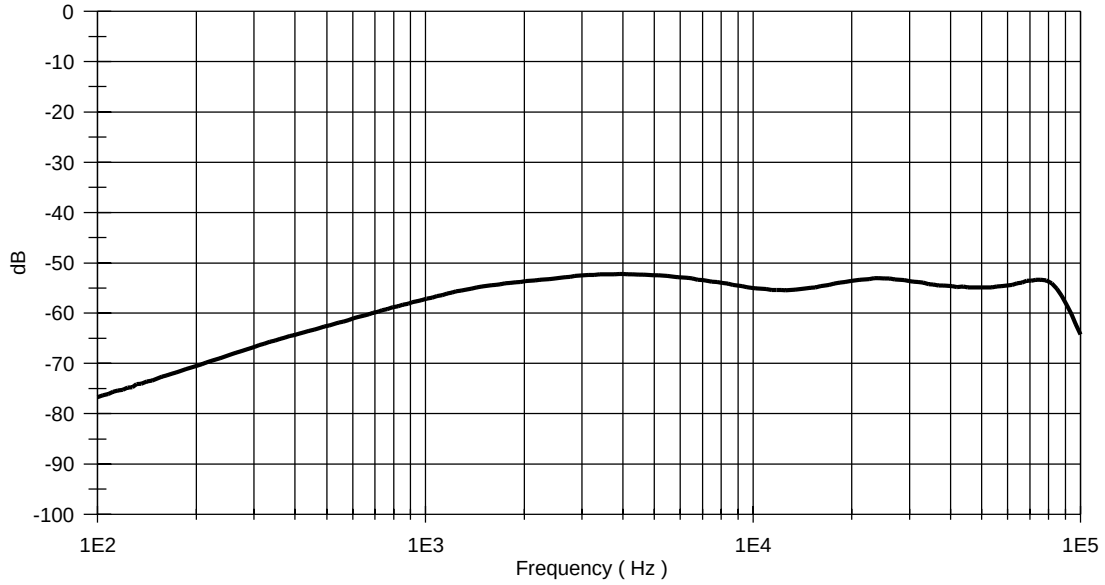
Block Diagram - Dual Output



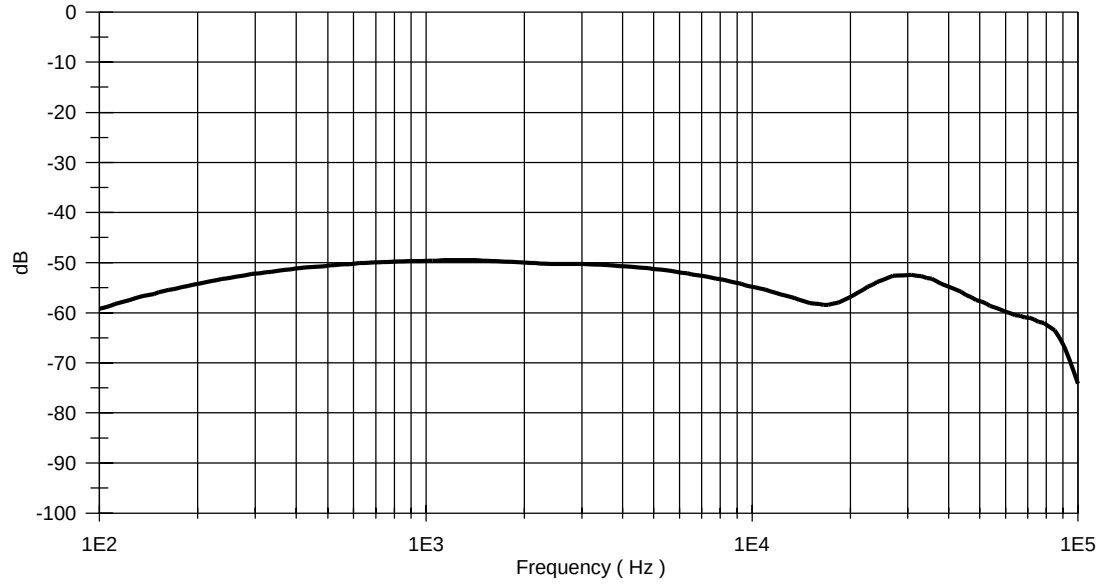
Conducted Emissions, Common Mode



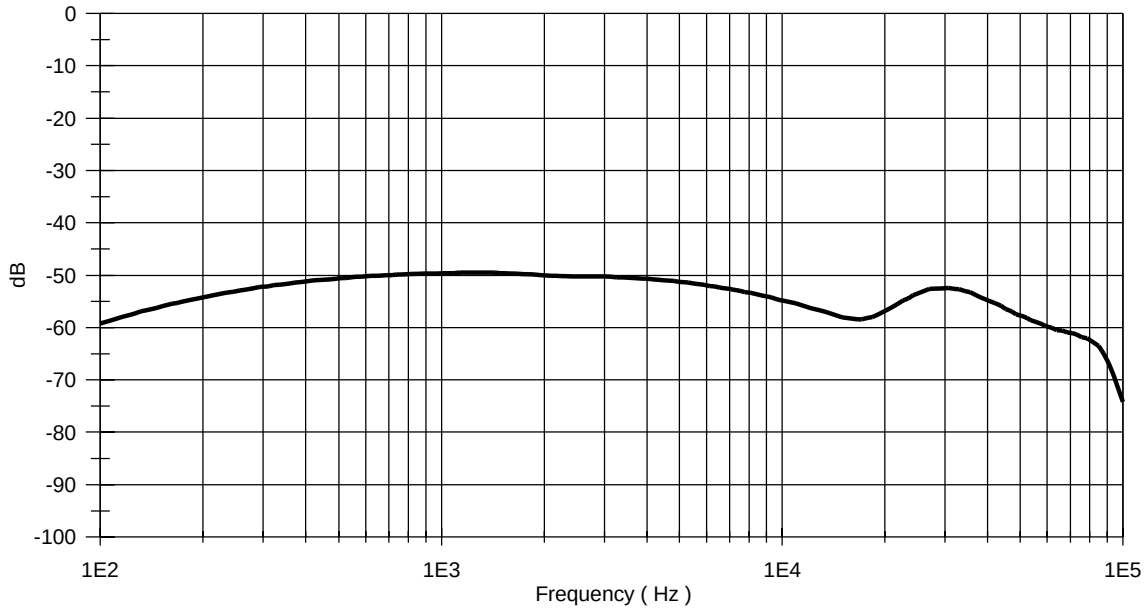
Conducted Emissions, Normal Mode



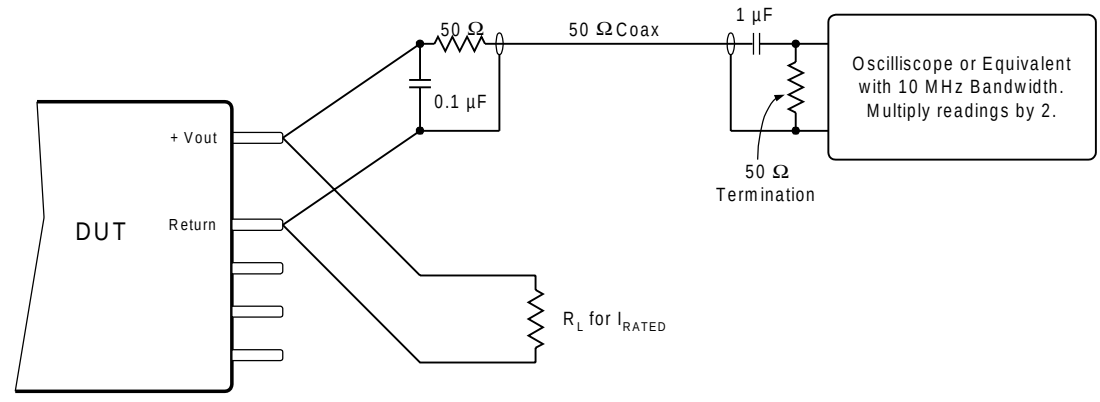
M3L2805S Line Rejection (CS01)



M3L2815D Line Rejection (CS01)

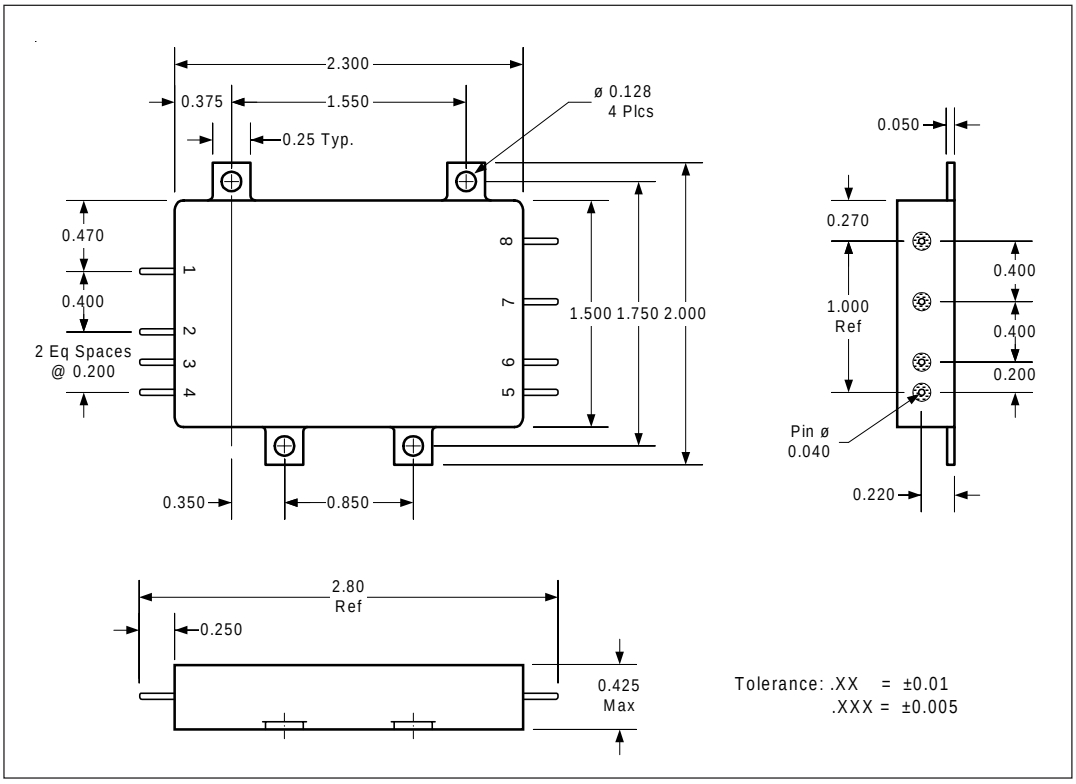


M3L2815D Line Rejections (CS01)



Circuit for Measuring Output Ripple Voltage

Mechanical Diagram



Pin Designation (Single/Dual)

Pin Number	Single	Dual
Pin 1	+ Input	+ Input
Pin 2	Input Return	Input Return
Pin 3	Case	Case
Pin 4	Inhibit	Inhibit
Pin 5	Output Adjust	Output Adjust
Pin 6	Output Return	- Vout
Pin 7	+ Vout	Output Common
Pin 8	NC	+ Vout

Part Number

M3L 28 05 S

- Model: M3L
- Input Voltage: 28 = 28V Nominal
- Output Voltage: 03R3 = 3.3V, 05 = 5V, 12 = 12V, 15 = 15V
- Outputs: S = Single, D = Dual

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